LMMN-BASED ADAPTIVE CONTROL FOR POWER QUALITY IMPROVEMENT OF GIRD INTERTIE PV SYSTEM

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ABSTRACT

This paper deals with the control of single-phase grid-tied solar photovoltaic (SPV) power generation system with an universal active power filter (UAPF) capabilities. The SPV- UAPF system consists of series and shunt voltage source inverters (VSIs). The shunt VSI exports the real power extracted from the PV panels to the grid and local loads. In addition to handling the real power, the shunt VSI provides compensation of reactive and harmonic currents generated by the loads. The reference signals required for the control of the shunt and series VSIs of the SPV-UAPF system are estimated using least mean mixed norm (LMMN) adaptive identification algorithm. The performance of the LMMN-based control of SPV-UAPF system with series shunt compensation capabilities is demonstrated using MATLAB/Simulink-based computer simulations and hardware- in-the-loop based experimental results under various operating conditions such as solar irradiance variation, voltage sag, swell and current harmonics.

Keyword: - *LMMN, PIC Micro Controller, Solar Panel, Boost Converter, Driver Unit, Storage Unit, Shunt Inverter, Series Inverter, Grid Supply, Crystal Oscillator, etc…*

1. INTRODUCTION

The ever-growing energy demand and emphasis on clean energy have led to proliferation of solar and wind based renewable power generations system. Between solar and wind energy systems, the solar energy systems are widely found at distribution level as they require little or no maintenance and the solar panels can be installed on almost any roof, as well as on the ground. Therefore, many households and commercial places are being powered by solar power [1]. The solar power generating systems make use of power electronics based dcdc and dc-ac converters to transform the dc voltage generated by the solar panels into an usable ac voltage [2]. The power electronic converters are controlled to operate the solar panels at maximum power point. In case of grid tied solar power generation systems, the voltage source inverters (VSIs) export the remainder of the extracted solar power to the distribution grid upon feeding the local loads. Usually for high power systems, three-phase is preferred as they offer reduced current stress on power electronic switches, improved efficiency, high power density and reduced passive elements size. Nonetheless,single-phase systems are suited for low power generation in the range of a few kilowatts. Most of the rooftop domestic solar power systems are low power and single-phase in nature. In single-phase systems, the number of power electronic switches and sensors required are less compared to a threephase system; which in turn makes the control circuitry simple and cost-effective. Thereby the complexity of the control system is reduced drastically in single-phase system. However, in case of single-phase systems, the instantaneous powers contain second order oscillations, which would lead to dc-link voltage oscillations in VSIs. To filter out these dc-link voltage oscillations a large capacitor bank is needed on dc side. Lately, the power quality has become a rising concern in distribution systems with the increased use of various nonlinear loads such as variable frequency drives, LED-based lighting devices and switch mode power supplies. The harmonic currents drawn by the nonlinear loads causes harmonic voltage drops in the system and thereby distort the voltage at point of common coupling (PCC). The voltage distortion caused by nonlinear loads may lead to malfunctioning of sensitive loads [3]. The effects of

harmonics drawn can be suppressed with the help of power quality conditioning devices such as series and shunt power filters. Installation of dedicated power conditioning devices can be avoided if the VSIs that are employed for the active power generation are able to offer ancillary services like harmonic and reactive currents compensation [4], [5]. Various studies focusing on integrating compensation capabilities in the VSIs of grid interactive solar power generation systems can be found in the literature [6]–[12]. Primarily, the attention has given to integration of shunt compensation capabilities like harmonic and reactive currents compensation to improve the voltage quality at the PCC as it does not require any additional component such as a series transformer. In [6]– [8], the solar power generation systems with integrated shunt compensation are reported. However, to deal with the voltage disturbances like voltage sag , swell and harmonic distortion, series compensation [9] is preferred over shunt compensation. Hence, to simultaneously provide both series and shunt compensation, universal active power filters (UAPFs) can be used [13]–[15]. UAPFs are capable of handling most of the power quality problems arise in distribution systems . In [10]–[12], a solar power generation coupled with both UAPF capabilities are proposed.

1.1 Existing System

In modern industries the electrical power systems are controlled by power electronics devices. These types of electronic controllers are sensitive in nature that cannot withstand sudden changes in voltage or due to poor quality of power the system will shut down. Due to excessive drop in voltage there exist power quality problems that leads to harmonic distortion in the power system. Power quality problems produces losses in an economical and also it effect the production of the quantities. The real or active power requires reactive power for the flow of power. The performance of the ac systems was improved by power and voltage should be maintained in an efficient manner. By maintaining the reactive power the power factor will be improved and it gives better voltage regulation.

1.2 Objective

The rest of this paper is organized as follows. Description of single-phase SPV-UAPF system is given in Section II. The proposed multi-channel LMMN adaptive algorithm based control scheme is presented in Section III, which includes control of shunt and series VSIs in addition to detection of harmonic components. In Section IV, design of overall system parameters is carried out. Section V presents the performance evaluation of SPV-UAPF system via simulation and experimental results using the proposed LMMN based control. Finally, conclusions are made in Section VI.

1.3 Contribution

Major contribution of the present work lies in the novel application of multi-channel LMMN filters in SPV-UAPF system wherein the LMMN filters are used for extracting harmonic components of voltage and current signals. The following list summarizes the contributions of the present work:

- Design and control of solar power generation system combined with UAPF capabilities for power quality improvement.
- Multiple LMMN filters-based structure is proposed and developed to achieve effective harmonics and reactive currents extraction.
- A single-phase phase locked loop (PLL) system is developed using multi-channel LMMN filters, which is immune to grid voltage harmonics.
- Validation and performance demonstration of the proposed method via simulation and experimental results.

2. LITERATURE SURVEY

As an existing photovoltaic (PV) system is upgraded to a residential PV/battery system, the single-phase PV inverter should satisfy the requirement of grid-connected operation under the battery input condition. Firstly, equivalent circuits of PV array and Li-ion battery pack are constructed and studied in this paper. Based on their equivalent circuit models, the impacts brought by the two different input conditions are compared. Under the battery pack input condition, the battery pack current may be more seriously contaminated by the second-harmonic due to the inherent power coupling problem in a single-phase inverter. Since the AC ripple current at the input side depends largely on the source impedance, the equivalent impedance of the ripple current is studied, then. Based on the small signal model of the boost DC-DC convertor, a novel active mitigating method for the input current ripple with double-channel current feedbacks is proposed. The extraction method of the ripple current and the rejection method of the

ac ripple voltage in DC link, based on a third-order general integrator, are analyzed and simulated in MATLAB. Finally, experimental results on a 5kW prototype validated the proposed control strategy.

The global electrical energy consumption is rising and there is a steady increase of the demand on the power capacity, efficient production, distribution and utilization of energy. The traditional power systems are changing globally, a large number of dispersed generation (DG) units, including both renewable and nonrenewable energy sources such as wind turbines, photovoltaic (PV) generators, fuel cells, small hydro, wave generators, and gas/steam powered combined heat and power stations, are being integrated into power systems at the distribution level. Power electronics, the technology of efficiently processing electric power, play an essential part in the integration of the dispersed generation units for good efficiency and high performance of the power systems. This paper reviews the applications of power electronics in the integration of DG units, in particular, wind power, fuel cells and PV generators.

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3. PROPOSED SYSTEM

Control of Single-Phase Solar Power Generation System with Universal Active Power Filter Capabilities using Least Mean Mixed-Norm (LMMN)-based Adaptive Filtering Method 90 degree lagging counterparts of voltage and current signals. No need for additional low pass filters and it is insensitive to PCC voltage distortions and frequency variations. Unlike the GIs based methods, the proposed method does not require a separate estimation of active and reactive harmonic currents as they are readily available from the LMMN filter structures. The proposed method also outputs peak values of the various harmonic signals extracted which would be highly useful in limiting the current through the shunt VSI. Exhibits superior dynamic and steady state performances in extracting harmonic and reactive currents.

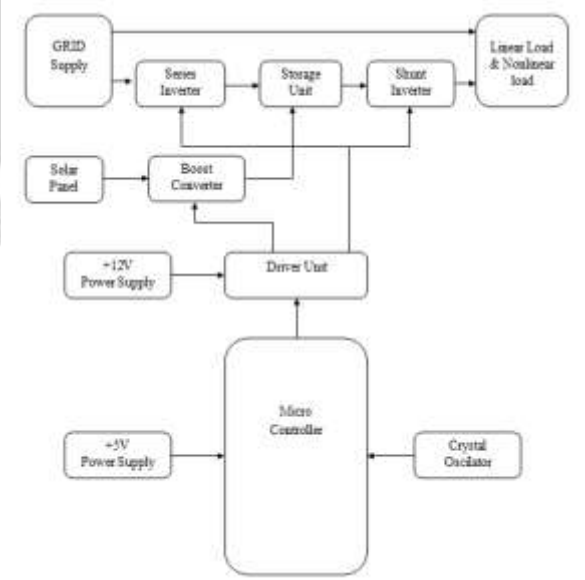

Fig.No. 1 Block Diagram For Proposed System

3.1 Advantages of Proposed System

- Power factor will be improved.
- It gives better voltage regulation.

4. RESULT & DISCUSSION

Fig.No. 2: Snapshot of Hardware Prototype

5. CONCLUSIONS

In this paper, a single-phase solar power generation system with integrated UAPF capabilities is designed and its performance using LMMN-based control algorithm is demonstrated. The PCC voltage and load current signals are effectively pro- cessed using multi-channel LMMN algorithm-based adaptive filter to estimate the compensating signals for shunt and series VSIs. Based on the simulation and experimental studies, it is evident that the SPV-UAPF system is able to successfully provide series-shunt compensation and load voltage regulation while simultaneously feeding the power extracted from the PV panels to the grid. The simulation and experimental results presented in the paper are shown to be in good agreement. The performance of the proposed LMMN-based control is compared with the conventional and reported methods to demonstrate its superiority in harmonic and reactive currents estimation. Despite the sudden and abrupt change in PCC volt- age, the proposed control algorithm could effectively regulate the load voltage magnitude. Further, the THDs of grid current and load voltage are well maintained below 5 .

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